T. BUNCLE AND CO. LTD., ARBROATH, ANGUS, SCOTLAND.

ED - S678.7T

MUS. COMP. ZOOL.
LIBRARY.

MAY 14 1971

HARVARD
UNIVERSITY

VOL. 18 PART 3

TRANSACTIONS

OF THE

SOCIETY FOR BRITISH ENTOMOLOGY

World List abbreviation: *Trans. Soc. Brit. Ent.*

CONTENTS.

A. R. Hill

The Bionomics and Ecology of *Anthocoris confusus* Reuter in Scotland

Date of Publication, December 1968.

Copies may be purchased from G. R. Gradwell, Hope Department of Entomology, University Museum, Oxford

Price 7/- post free

Published for the Society
by the British Trust for Entomology Ltd.

THE BRITISH TRUST FOR ENTOMOLOGY

ADDRESSES

REGISTERED ADDRESS—41 Queens Gate, London, S.W.7.

EDITORIAL—The Editor: Dr. E. J. Popham, Dept. of Biology, The University, Salford, Lancs.

Sub-Editors: Dr. R. R. Askew and Dr. J. H. Kennaugh, Dept. of Zoology, The University, Manchester 13.

SUBSCRIPTIONS, SALES and MEMBERSHIP—The Secretary, G. R. Gradwell, Hope Dept. of Entomology, University Museum, Oxford.

PUBLICATIONS

THE ENTOMOLOGIST. Published monthly, one volume per annum. Subscription rate 35/- per annum.

THE TRANSACTIONS OF THE SOCIETY FOR BRITISH ENTOMOLOGY. Published irregularly, one volume every two years. Subscription rate 30/- per annum.

Members of the Trust may subscribe to both periodicals at a combined subscription of 55/- per annum.

COUNCIL OF MANAGEMENT

Chairman: G. C. Varley, M. A., Ph.D., F.Z.S., F.R.E.S.
R. R. Askew, B.Sc., D.Phil., F.R.E.S.
M. F. Claridge, B.A., D.Phil., F.R.E.S.
R. A. French, B.Sc., F.R.E.S.
G. R. Gradwell, M.A., F.R.E.S.
B. M. Hobby, M.A., D.Phil., F.L.S., F.Z.S., F.R.E.S.
G. J. Kerrich, M.A., F.L.S., F.R.E.S.
H. N. Michaelis.
E. J. Popham, D.Sc., Ph.D., A.R.C.S., F.Z.S., F.R.E.S.
N. D. Riley, C.B.E., F.Z.S., F.R.E.S.
T. R. E. Southwood, D.Sc., Ph.D., A.R.C.S., F.R.E.S.
H. F. van Emden, B.Sc., Ph.D., A.R.C.S., F.R.E.S.

Other members of the editorial board:

A. Brindle, F.R.E.S.
A. E. Gardner, F.R.E.S.
H. E. Hinton, B.Sc., Ph.D., Sc.D., F.R.S., F.R.E.S.
C. Johnson, F.R.E.S.
H. B. D. Kettlewell, M.A., M.B., B.Chir., F.R.E.S.
M. J. Parr, B.Sc., F.R.E.S.
O. W. Richards, M.A., D.Sc., F.R.S., F.R.E.S.

TRANSACTIONS OF THE SOCIETY
FOR BRITISH ENTOMOLOGY

VOL. 18 DECEMBER 1968 PART III

The Bionomics and Ecology of *Anthocoris confusus* Reuter in Scotland

II LIFE HISTORY AND POPULATION CHANGES

By A. R. Hill
(Zoology Department, The University, Glasgow)

Introduction

In an earlier paper (Hill, 1965) an account was given of the activities of the adults of *Anthocoris confusus* Reuter, especially that of oviposition in the spring and summer. The present paper continues with a study of the life history of this insect and includes observations on seasonal population fluctuations in the field, under Scottish conditions. These observations were again made in the oak wood near Drymen, Stirlingshire (Grid. Ref. 485880).

Materials and Methods

Details have already been given (Hill, 1965) of the method of collecting and sampling the populations in the field. In the rearing experiments the immature stages were kept individually in gelatine capsules 1″ long × $\frac{1}{4}$″ diameter, each of which was fitted with a small slip of filter paper which provided a secure foothold for the larval bug and its prey. A fresh supply of food was provided daily, in quantities which ensured that there was always a surplus unconsumed at the end of the 24-hour period. Care was also taken to provide prey of a size appropriate to the size of the predators. The contents of the capsules were examined daily to note the occurrence of ecdysis and the numbers of prey organisms attacked during the previous day.

Observations on life cycles were made in three locations: (a) out of doors in an open-sided insectary; (b) in a warm constant temperature room running at 22°C; (c) in a laboratory where daily temperature fluctuations were slight. Temperature records were made in all three locations by means of recording thermographs.

Life-History

Incubation period

The main rearing experiments were performed between 2nd June and 8th August, which spans the period when the majority of larvae are developing in the field. Ova maintained in the laboratory hatched on average in 5·7 days but the incubation period varied between 4 and 8 days (fig. 1).

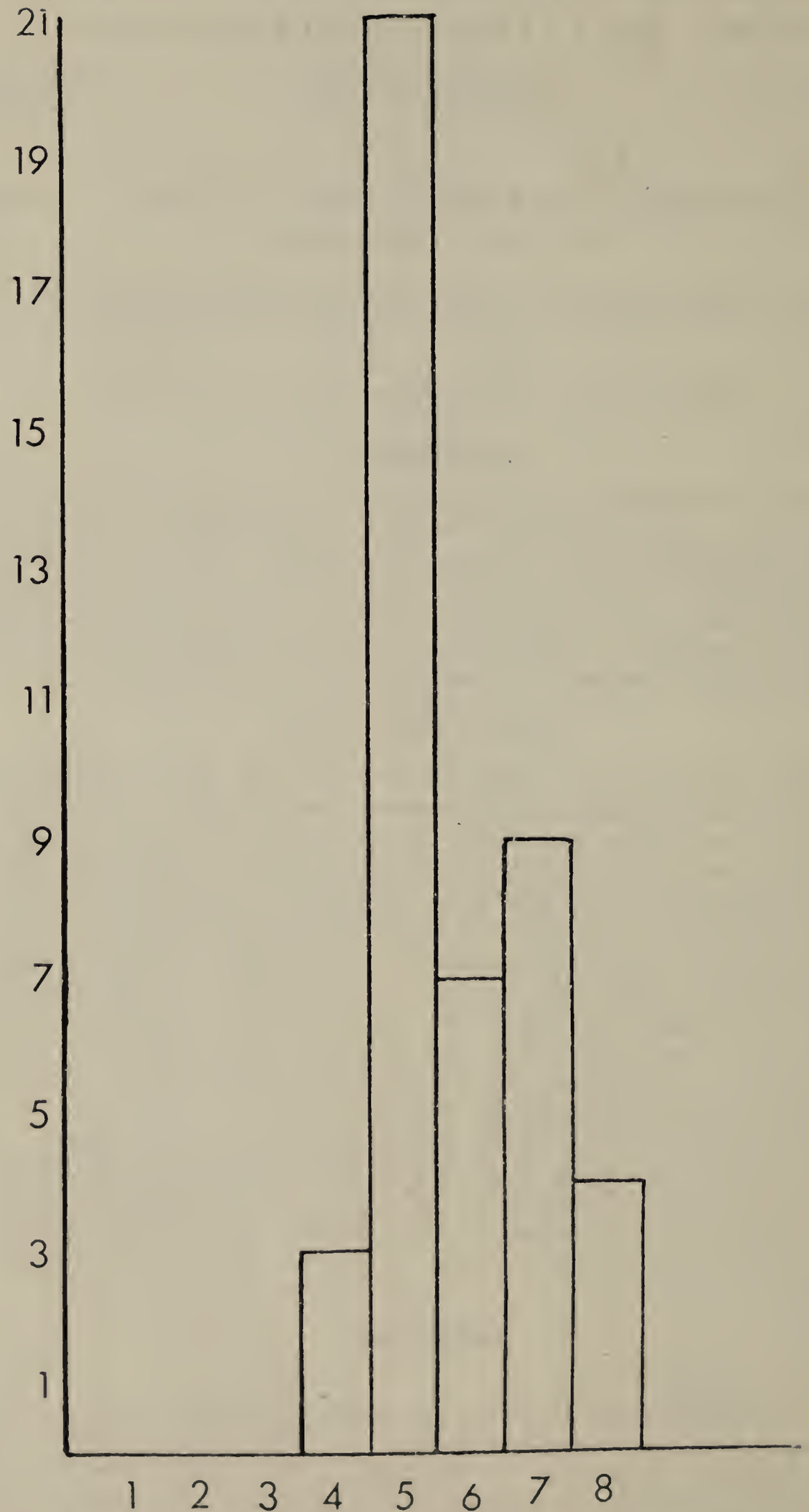


FIG. 1—Frequency distribution histogram of incubation periods in days of ova kept in an unheated laboratory in June.

In the field, however, egg-laying begins much earlier, usually just before the middle of May, at which time the average temperature is lower than it was during the period of the experiments described here. Eggs laid at the beginning of the season naturally require a longer incubation period, and it was found from numerous observations that this ranged between 12 and 22 days with an average of 18·4 days (fig. 2).

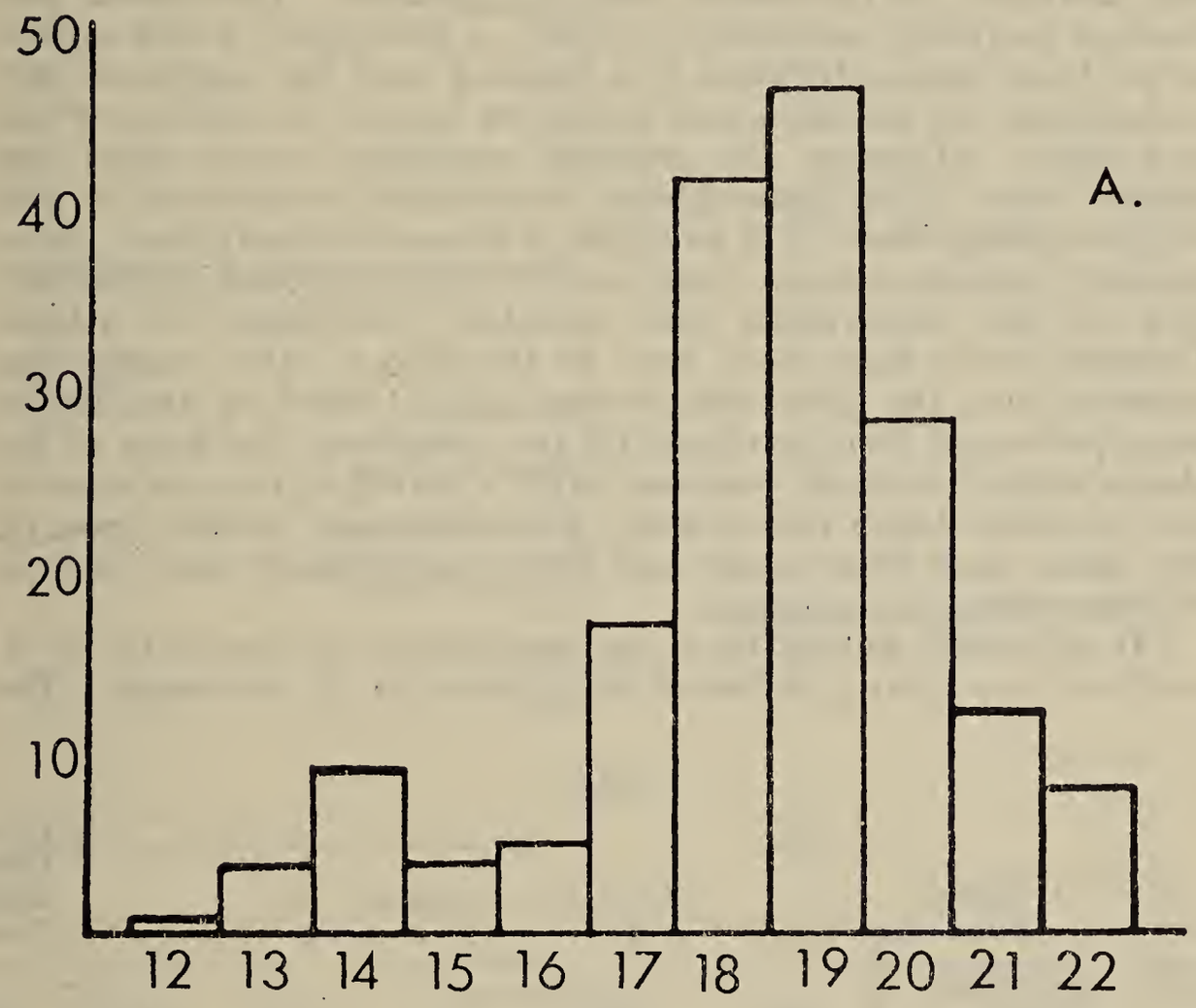


Fig. 2—Frequency distribution histogram of incubation periods in days of ova kept in an open-sided insectary simulating field conditions, in May

Egg Mortality

A series of observations was made on the amount of egg mortality which occurred under the conditions in the culture tubes in the insectary. As in the previous experiment (Hill, 1965) each gravid female was kept in a 3″ × 1″ corked phial provided with a moist disc of filter paper. Into each tube was placed a short length of stem of *Crataegus monogyna* Jacq. The tubes were examined daily and the numbers of eggs laid during the previous twenty-four hours were noted. The eggs, together with the piece of stem and/or the filter paper were then removd to a rearing tube which was labelled appropriately. The eggs were examined daily thereafter and the dates of hatching were recorded as were data about failures. Of all the eggs laid, 14% were

deposited on the surface of the plant stems and 44% of these were sucked by the mothers within one day of being laid. Likewise 36% of the eggs were laid on the surface of the filter paper and 39% of these were also sucked. 20% of all the eggs laid were thus destroyed within twenty-four hours by the females which laid them. Of the remainder 21·5% hatched. 25% of the eggs laid in the plant tissue hatched as did 22% of those laid on the plant stems. Of those laid on the surface of the filter paper but not destroyed by the female, only 7% hatched. The overall percentage mortality amounted to 82·8%. This figure would appear to be high, especially when it is recalled that the eggs were protected from all parasites and predators except the females which laid them. However, the artificial conditions under which the insects were living undoubtedly contributed somewhat to this high mortality level. For example, it is most unlikely that, under natural conditions many eggs would be laid exposed on the surface of the substratum and therefore vulnerable to attack. Certainly none have been seen in the field. Also, many eggs inserted into the plant tissue were either killed or the larvae were prevented from hatching by the unnatural shrinkage of the stems which inevitably occurred after a period of time, in spite of the humidity being maintained. In other cases moulds grew on the stems and filter paper and these undoubtedly also had an adverse effect on the eggs.

It is worth noting that the egg-laying requirements of *A. confusus* are clearly different from those of *A. nemorum*. The

TABLE 1

Location	Duration Food	Duration of Stadium No. 1	2	3	4	5	Larval Developmental Time
Insectary	Average Duration	6·85	5·52	6·0	6·85	14·15	39·37
	Range	4-8	3-7	5-7	6-8	13-16	36-45
	Average No. of Prey killed	23·43	17·71	18·08	16·15	34·46	114·77
	Range	21-32	9-24	9-32	9-26	23-50	87-132
Laboratory	Average Duration	3·53	3·0	3·13	3·87	8·2	21·73
	Range	3-5	2-4	2-4	3-5	7-9	18-25
	Average No. of Prey killed	22·4	19·13	21·93	26·07	36·86	126·29
	Range	14-33	14-31	7-31	15-42	19-57	96-144
Constant Temperature Room	Average Duration	3·57	2·14	2·43	3·43	6·71	18·28
	Range	3-5	2-4	1-3	2-4	6-8	15-21
	Average No. of Prey killed	24·4	16·14	18·5	25·0	38·78	122·86
	Range	14-33	12-27	2-28	16-34	19-57	94-145

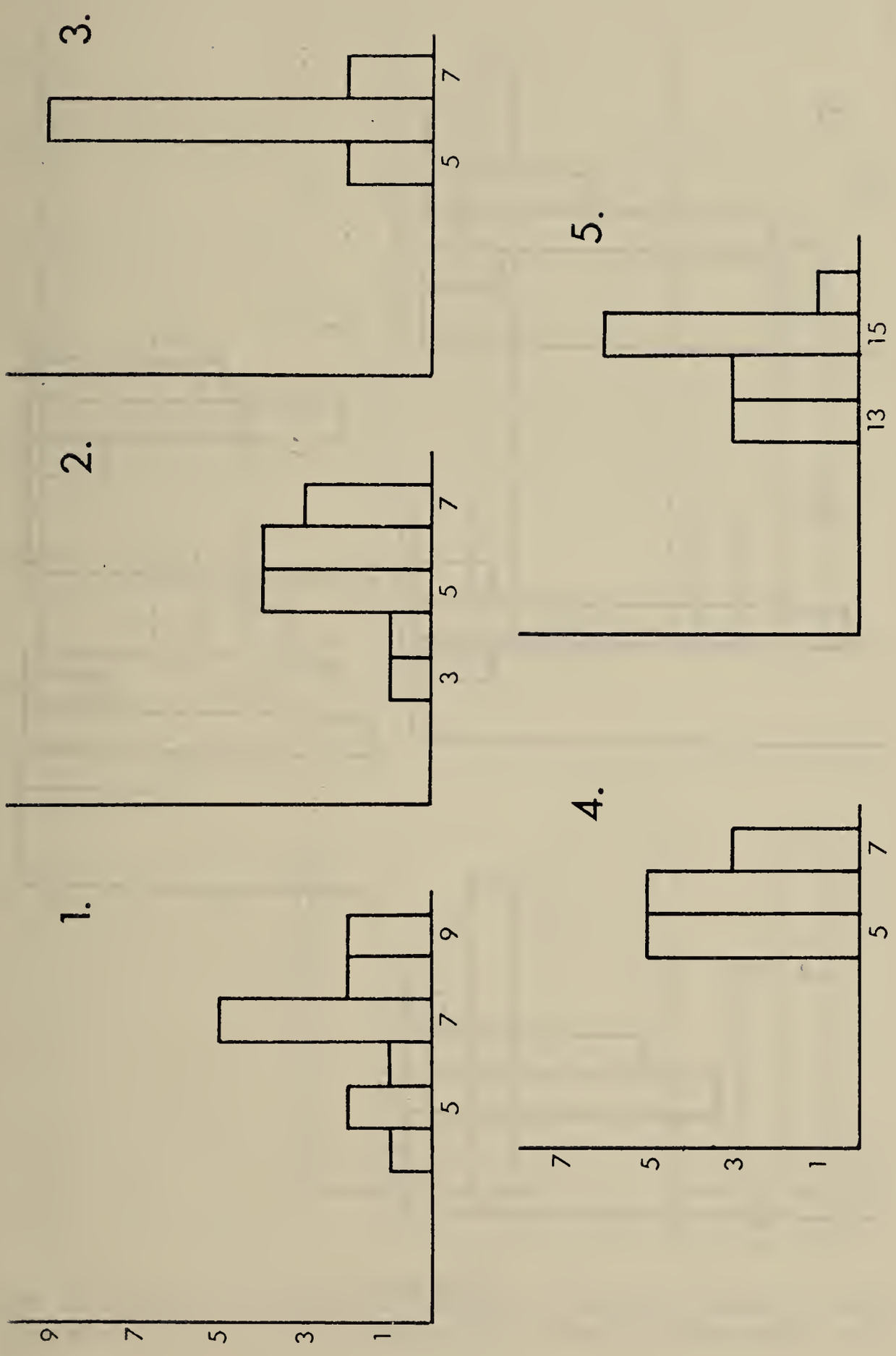


FIG. 3a

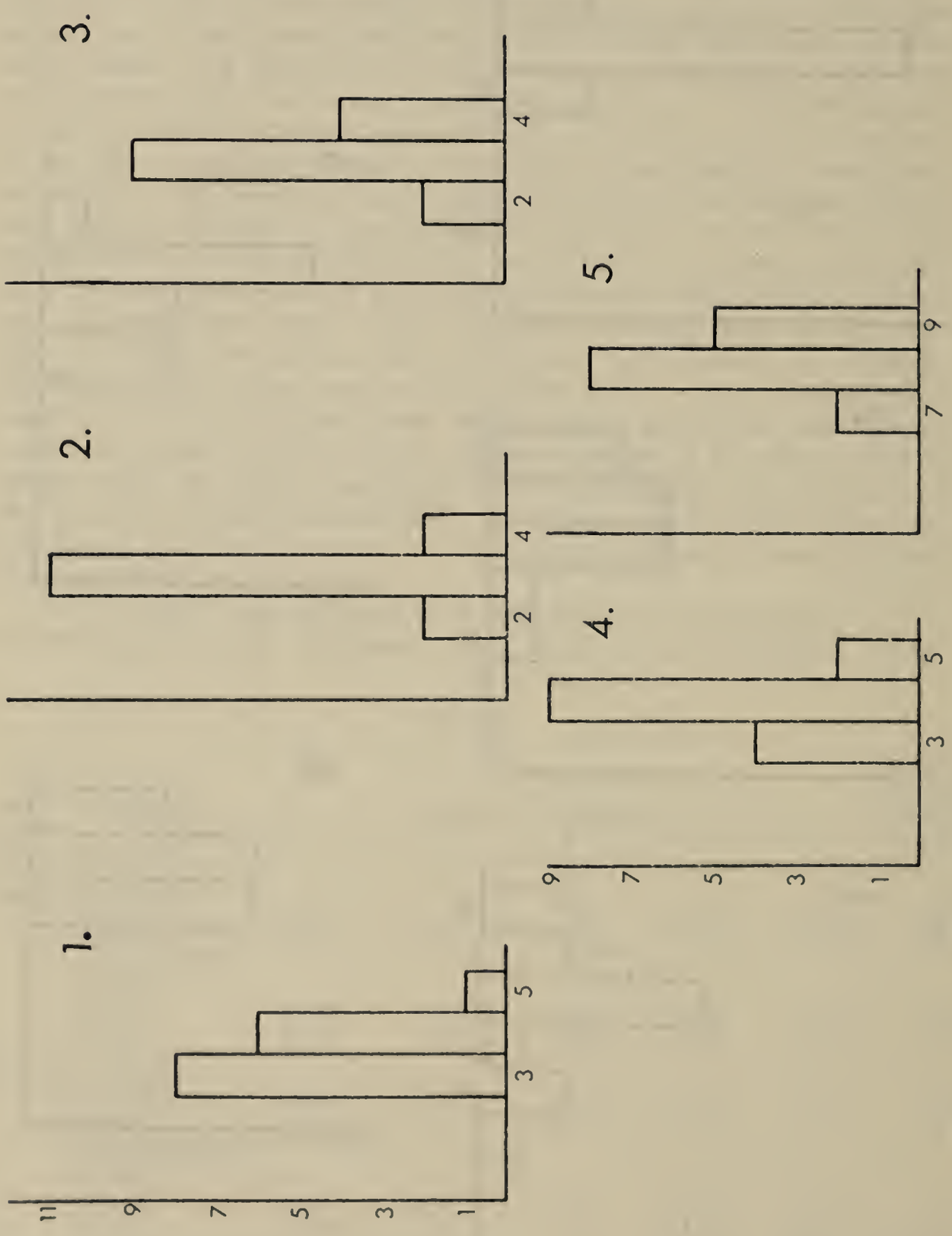


FIG. 3b

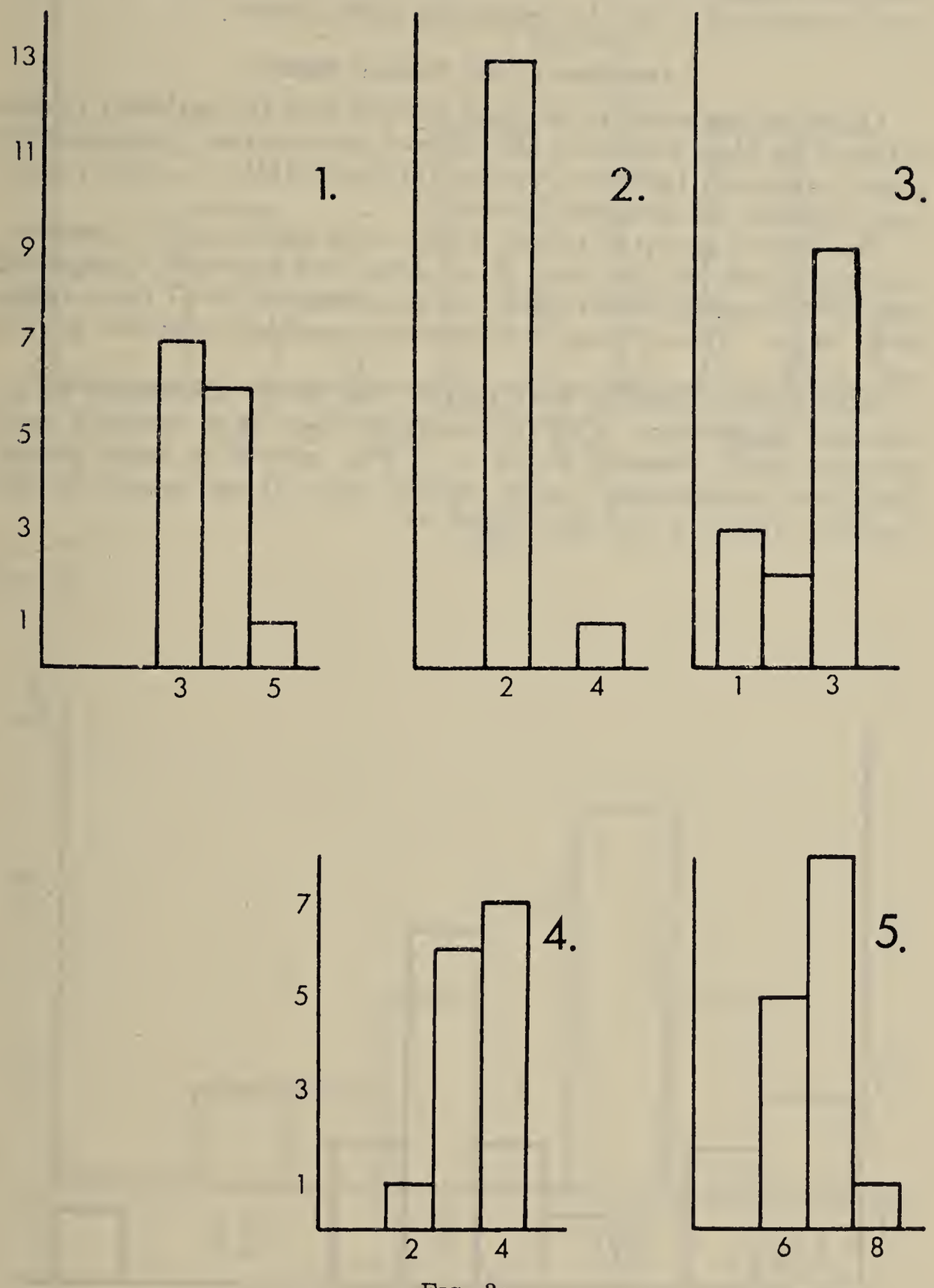


FIG. 3c

FIG. 3—Frequency distribution histograms of duration of stadia in days: (a) insectary; (b) unheated laboratory; (c) constant temperature room.

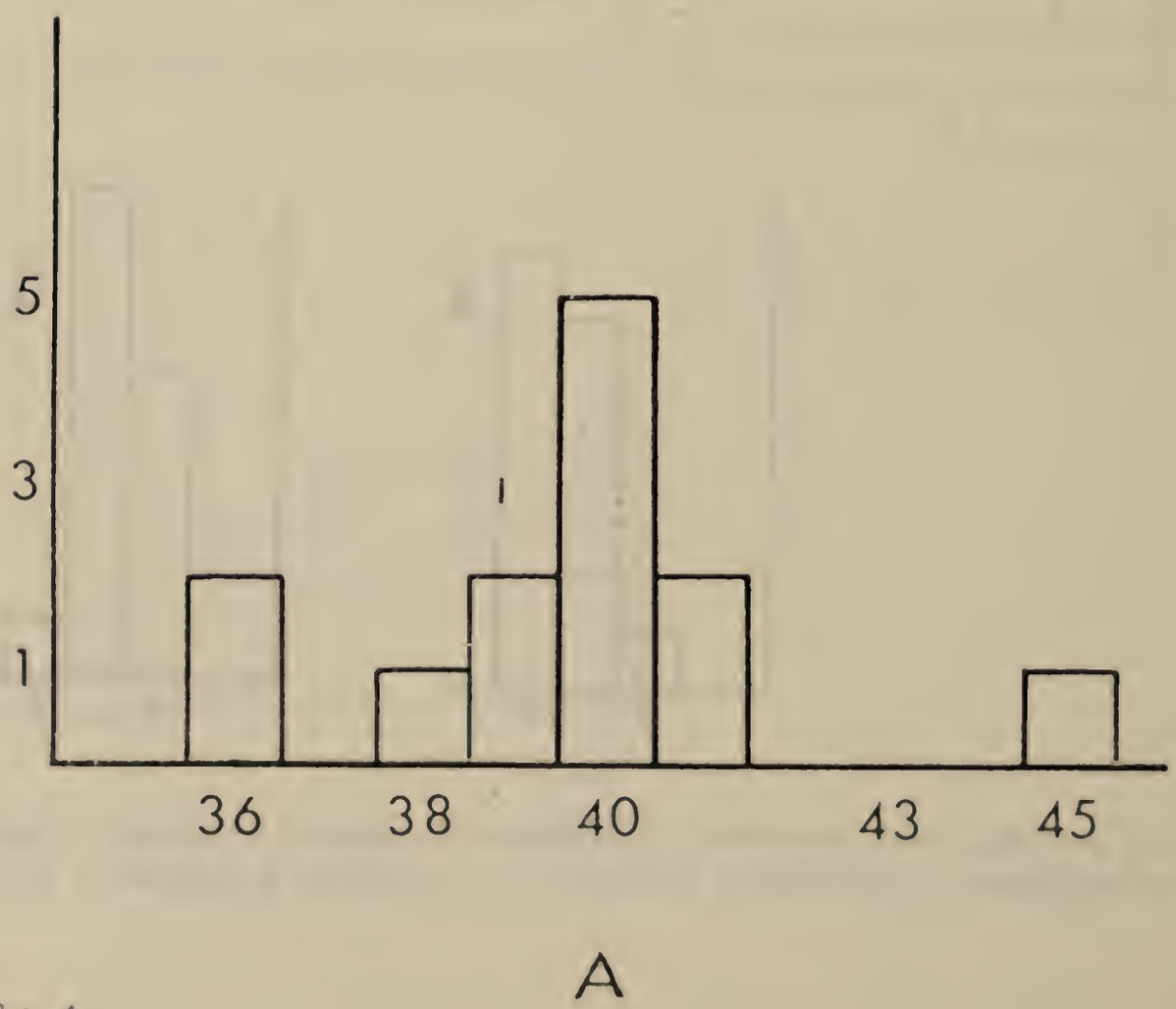
latter species readily accepts moist filter paper as a medium in which to insert its eggs and requires no plant tissue, whereas *A. confusus* females never inserted eggs in the filter paper and can best be induced to lay by supplying plant tissue.

Duration of the Various Stadia

Observations made in the field showed that the earliest nymphs hatched on May 11th and the first of the summer generation of adults appeared between August 10th and 16th, i.e., 60-67 days were required to complete growth.

However a group of larvae which were reared in the insectary somewhat later in the year, from June 2nd onwards, completed their development more rapidly, in an average of 39·37 days, range 36-45 days. The average temperature recorded over the period was 11·7 °C.

Two further batches were reared, one in the laboratory at an average temperature of 16·7 °C. and the other in a constant temperature room running at 22 °C. The insects in both groups developed significantly more rapidly than those reared in the insectary (table 1 and figs. 3 and 4).



A

FIG. 4

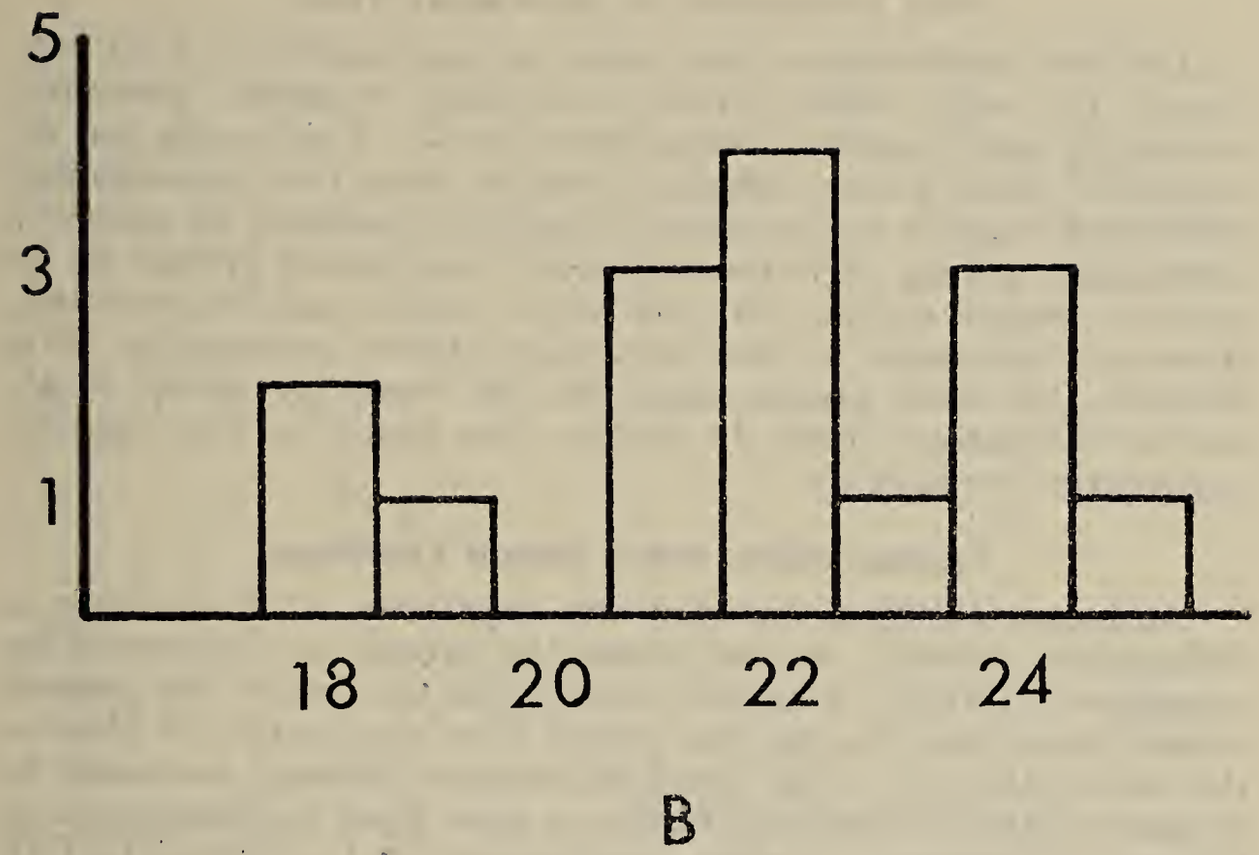


FIG. 4.

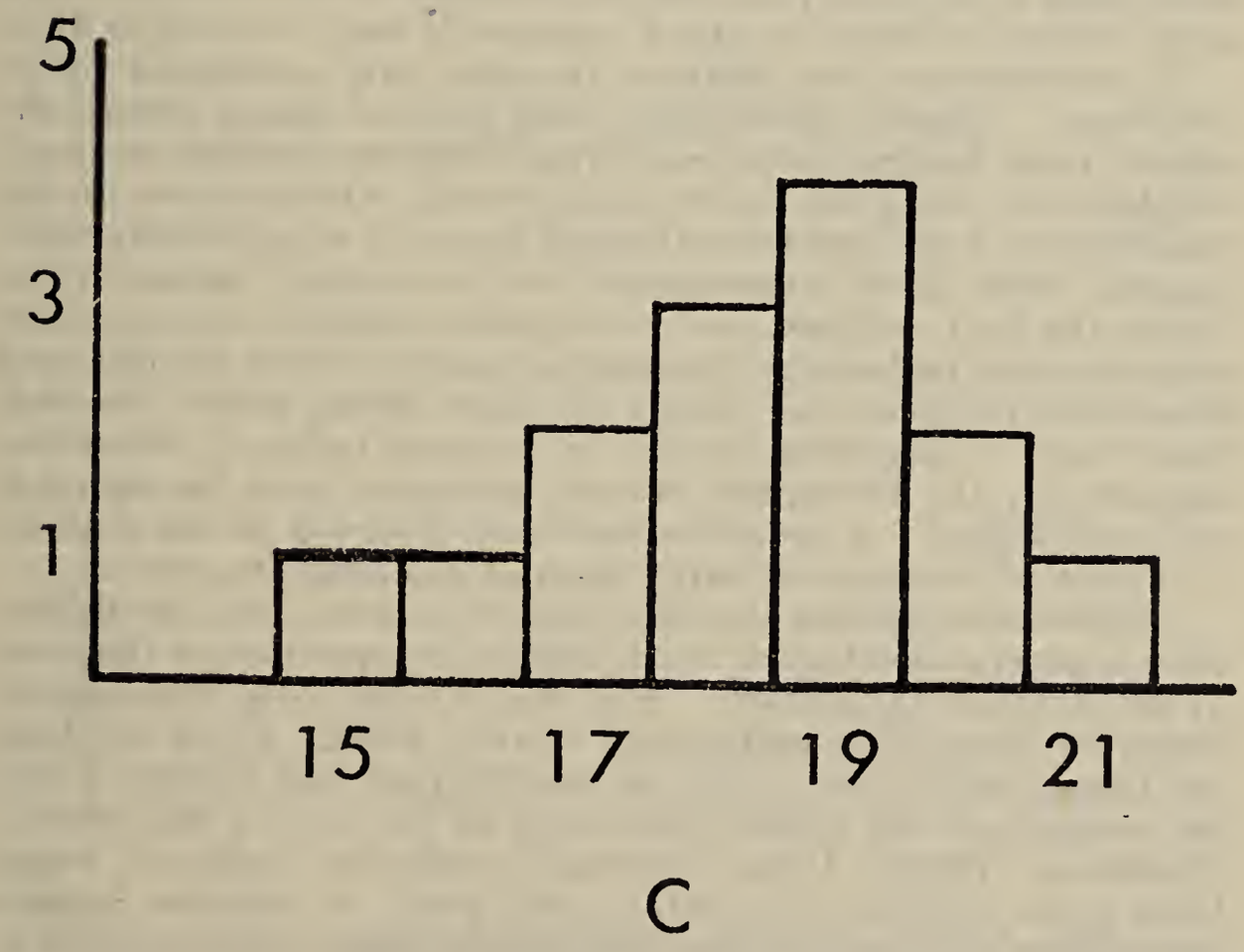


FIG. 4—Frequency distribution histograms of times in days taken for complete larval development: **(A)** insectary; **(B)** laboratory; **(C)** constant temperate room.

Food Consumption in the Culture Tubes

Detailed observations were made on the amount of food consumed by each instar under the three régimes, insectary, laboratory and constant temperature room. The results are included in table 1 from which it can be seen that considerable differences exist in the numbers of aphids consumed by different individuals during their development; this would appear to be directly related to the duration of the individual life histories. However, the range in food consumed differs remarkably little between the three groups, that for the insectary group is 45, for the laboratory group 48 and for the group in the constant temperature room is 51.

Feeding Habits under Natural Conditions

Anderson (1962) states that the chief prey of *A. confusus* is Callaphidid aphids; on oak trees the species is *Tuberculoides annulatus* (Hartig). This was found to be the case in the present investigation also, during the period from the middle of May to the end of October. The aphid population annually increased to a peak in July. The high numbers were then maintained until the end of October, by which time adults of *A. confusus* had all entered hibernation. Aphid numbers then normally dropped abruptly to zero during the first half of November. These observations differ from those reported by Anderson for the Silwood Park area. There, a decline in aphid numbers is said to occur in July.

T. annulatus is not however the only prey consumed by *A. confusus*. Clearly, during the early part of spring before the aphids have hatched and even when they are present in small numbers, the bug must resort to other food. Observations on the constituton of the general arthropod fauna of oaks at that time, together with direct observations on the feeding habits of the bug in the field, indicate that Psocoptera constitute its main diet, supplemented perhaps by Collembola, both of which are the most abundant species on oak during the early spring before the buds have burst. Collembola decline in numbers before *T. annulatus* appears but the Psocoptera remain abundant until the aphid is well established. *A. confusus* has been observed in the field on a number of occasions in early Spring consuming Psocoptera.

Anderson suggested that the lack of suitable food, as distinct from a general shortage of food, induces a reproductive diapause in the summer generation. This was a reasonable assumption, based on observed conditions at Silwood Park. There the bugs are forced "to probably feed on leaf-hoppers and Psocids which far outnumber the aphids from July to the end of the season" (Anderson, 1962). Under Scottish conditions, however, where there is no shortage of suitable aphid prey, *A. confusus* females nonetheless also enter a reproductive diapause. This is taken to indicate that the response is not to a shortage of food, but to some other factor, probably changing photoperiod. That photoperiod might also be responsible for reproductive diapause in the Silwood

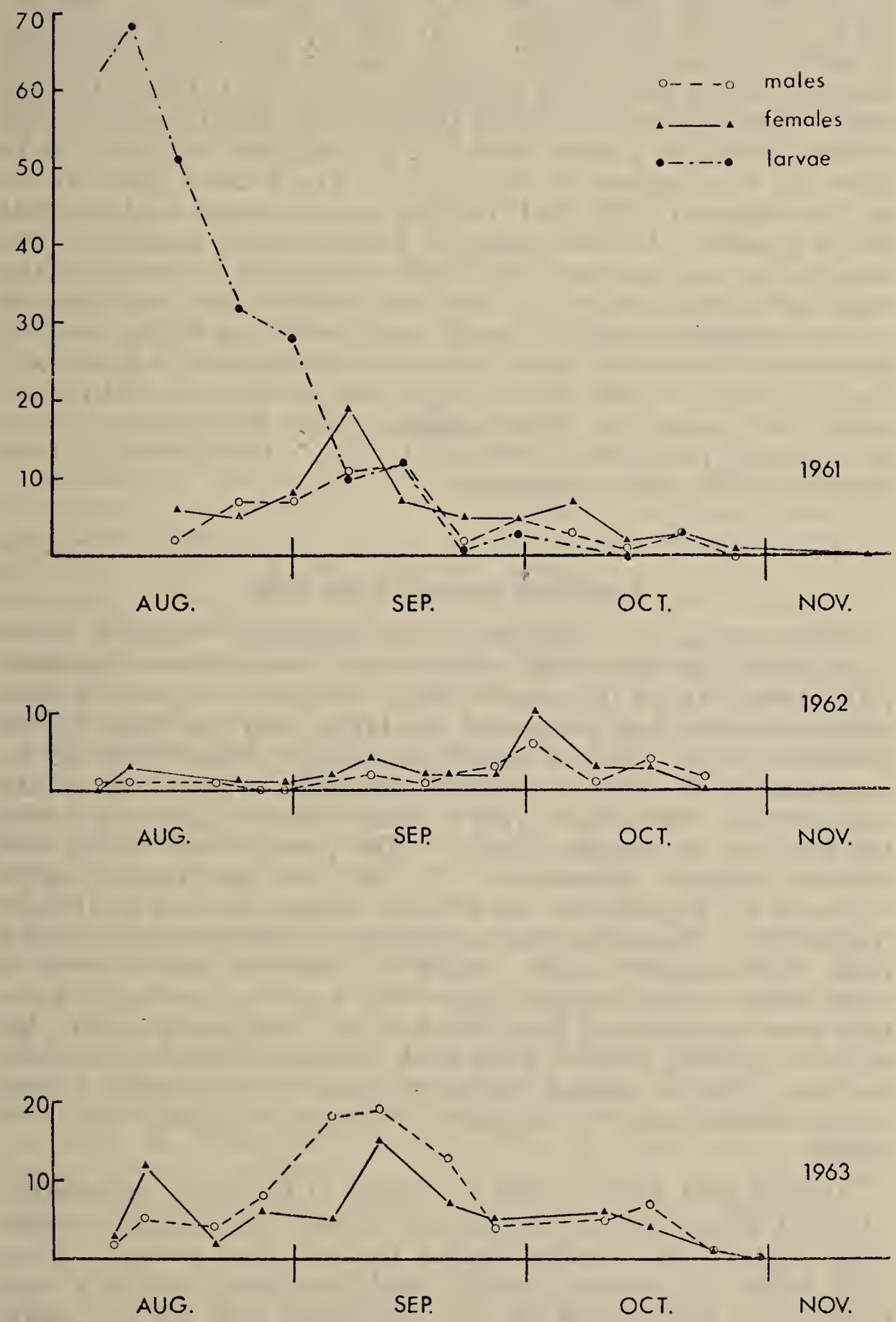


FIG 5—Graphs showing changes in the numbers of summer adults in the field during the years 1961-1963.

Park population may be inferred from Anderson's statement that "a portion of the females produce a second generation . . . maturing in late July and August". It can be postulated that these females may be the first to have reached maturity during the summer, having developed from the earliest laid batches of spring eggs, and having passed entirely through their growth and developmental period at a time when the photoperiod was such as to allow the development of the ovaries. The writer's observations of *A. sarothamni* (Hill, 1961) provide circumstantial evidence that this is possible. In that species, a partial second generation was observed in one year only, viz., 1959, which had an exceptionally warm and long summer. In the light of subsequent experience it is now suggested that the small number of egg-laying summer generation females of *A. sarothamni* did not represent a genetically distinct group, as was then thought, but rather were individuals which had passed the critical stage in their development before the changing photoperiod influenced them. Development of their ovaries was therefore uninhibited.

Population Changes in the Field

Observations on emergence and population changes of *A. confusus* during the spring months have already been discussed (Hill, 1965). In all the years of study the great majority of overwintered adults had completed egg-laying and had died by the middle of June. Only a small percentage, already referred to, continued to be active until late summer. Indications of the emergence of the current year's adults began to be seen during the first half of August (fig. 5). The precise date varied with seasonal climatic differences. In 1961 the first teneral adults appeared on August 16th, in 1962 on August 6th and in 1963 on August 8th. Thereafter the population increased steadily until a peak was reached usually during the first or second week of September. In the atypical year 1962, however, maximum numbers were not recorded until October 1st. Not unexpectedly, because of climatic factors, these peak numbers were not sustained for long; quite a marked diminution was evident within a week and continued until, by the end of October, no adults were to be found.

During 1961 records were also made of the larval population. The first larvae appeared on May 11th but only a slight increase in larval numbers occurred during the next four weeks. Larvae then began to increase rapidly and maximum numbers were recorded on August 10th (fig. 5). Thereafter with the progressive increase in the population of summer adults, larval numbers decreased more or less proportionately. Larvae did not finally disappear, however, until the middle of October. Larvae collected in the field on October 6th were reared in the laboratory to ensure that they were in fact *A. confusus*.

Sex Ratio

In two years out of three under review, males and females emerged practically simultaneously. In 1962, however, the first males were collected four days before any females were found. In 1961 and 1962 females outnumbered males during the period of the summer increase in the adult population; in 1963, however, the reverse was the case (see table 2).

TABLE 2

Sex Ratio of Summer Adults

	♂	♀
1961	1	1·4
1962	1	1·23
1963	1	0·76

Voltinism

Laboratory observations demonstrated that under certain conditions it is possible for *A. confusus* to produce a second generation. During the course of this study, however, only a minority, 12·5%, of the summer females oviposited in the laboratory. The exact conditions inducing the production of a second generation are being investigated but it is perhaps significant to note that the females which initiated the second generation were the earliest members of the first generation to reach maturity, which they did on July 10th, 12th and 15th —much earlier than would be possible under field conditions (see above). None of the other females laid ova and the majority of them died after periods ranging from 7 to 39 days. There is no clear indication that a second generation can occur in the field under Scottish conditions. It is true that late 4th instar larvae can be found annually until about the middle of October, but after that they abruptly disappear, either going into hibernation or succumbing to inclement weather. It is most probable that such larvae hatched from the latest ova laid by a few exceptionally long-lived, over-wintered females (Hill, 1965). It could be argued, however, that their parents were among the first members of the summer generation to reach maturity in early August. As a period somewhat in excess of 40 days would be required to attain their state of development, namely the 4th instar, they would require to have hatched from eggs laid certainly not later than August 28th and most likely considerably earlier, because the average temperature during their development period in September and October would be distinctly lower than that experienced by larvae developing in June and July. The overlap between the last of the over-wintered females and the first of the summer generation females makes it difficult to be dogmatic on this point. However, as the individuals reaching maturity earliest in the field do so well after the summer solstice, it would seem most likely that they will enter a reproductive diapause, so

that in fact the late larvae are most probably the last of the progeny of long-lived, over-wintered females. Moreover, at Silwood Park, Anderson (1962) reported that " . . . a proportion of the population produces a second generation . . . maturing in late July and August". These correspond closely in the time of their final ecdysis with our Scottish first generation insects and, as the Silwood Park insects did not produce a third generation, it seems reasonable to conclude that a further (i.e., second generation) is unlikely to occur in Scotland.

Summary

(1) Observations on the life history of *A. confusus* are described and details of the duration of the incubation period and the several stadia are given.

(2) Information is included on the consumption of prey and on the feeding habits of adults and larvae in the field.

(3) An account is given of population changes which occur in the field.

(4) It is argued that, under Scottish conditions, *A. confusus* is univoltine.

Acknowledgments

I wish to express my thanks to Mr. and Mrs. Monerieff Mitchell for permission to carry out the investigation on their land. I am indebted to Mr. P. S. Meadows and Mr. Gordon Ross for technical assistance in the laboratory and insectary and to Mr. Swang Wangboonkong for repeating some of the rearing experiments. I am very grateful to the Agricultural Research Council for a financial grant in aid of the project.

References

Anderson, N. H. 1962. Bionomics of six species of *Anthocoris* (Heteroptera: Anthocoridae) in England. *Trans. R. ent. Soc. Lond.*, **114**, 67-95.

Hill, A. R. 1961. The Biology of *Anthocoris sarothamni* Douglas and Scott in Scotland (Hemiptera: Anthocoridae). *Trans. R. ent. Soc. Lond.*, **113**, 41-54.

Hill, A. R. 1965. The Bionomics and Ecology of *Anthocoris confusus* Reuter in Scotland. 1. The adult and egg production. *Trans. Soc. Brit. Ent.*, **16**, 245-256.

MCZ ERNST MAYR LIBRARY
3 2044 118 699 107

Date Due